Dryden Flight Research Center
Edwards, California 93523-0273

DHB-O-001
Revision: A

DRYDEN HANDBOOK

CODE O

OPERATIONS ENGINEER'S HANDBOOK

Electronically approved by
Director, Flight Operations Directorate

Before use, check the NASA PBMA web site
at http://pbma.nasa.gov for the current revision.

DOCUMENT HISTORY PAGE

This page is for informational purposes and does not need to be retained with the document.

Date Approved	Issue	Page	Amendment Details
8/17/00	Baseline		
See IDMS Document Master List	Rev A	All	Deleted references to DOP-O-505 (obsolete) pages 2 and 13 and replaced with DCP-S-018. Added Document History page. Minor text edits throughout.

TABLE OF CONTENTS

1.0 INTRODUCTION

The purpose of this handbook is to describe the duties of the Operations Engineering Branch. It is a reference for Operations Engineers, other employees at the Dryden Flight Research Center, and guest employees for aid in achieving project goals.

The handbook is available to Dryden staff and to the public on the Interactive Document Management System (IDMS), a compilation of policies and procedures that govern the conduct of business at the Center. This handbook refers to documents in the IDMS that are hyper-linked with this text for easy access using the Dryden Intranet.

2.0 WHAT IS AN OPERATIONS ENGINEER?

Operations engineers are assigned members of project teams consisting of project managers, engineers, mechanics, technicians, and artisans. The operations engineer is the Flight Operations representative who identifies, assigns, and coordinates the tasks that must be done to get a vehicle ready to conduct its mission. The responsibility requires in-depth knowledge of the organization, skills, and science required to make a unique research aircraft safe and successful. The duties require the operations engineer to work directly with all project team members, particularly the crew chief, project manager, and the project chief engineer, as well as the craftsmen, other engineers, and mechanics that support the project. These duties consist of six major functions:

- Aircraft technical management
- System safety
- Flight readiness
- Flight support
- Post flight activity
- Peripheral activities

3.0 AIRCRAFT TECHNICAL MANAGEMENT

As the technical manager of an aircraft the operations engineer:

- Controls configuration to ensure that the vehicle can successfully and safely perform its missions
- Schedules work to ensure timely achievement of objectives
- Coordinates activity to avoid conflict in commitments and tasks
- Informs crews and researcher investigators of the configuration of the aircraft, the operating characteristics, and the operating limitations

This function is not to be confused with the role of the aircraft crew chief, who is responsible for the maintenance and servicing of the aircraft, the logs, and records. The operations engineer maintains close consultation with the crew chief for understanding of the aircraft systems, configuration, and condition. He also writes and approves aircraft work orders that allow the crew chief to do special work to implement changes to the aircraft that are not routine maintenance or repair.

The configuration is managed according to a configuration management plan prepared by the project manager for research vehicles, or by the operations engineer for support aircraft. This is discussed in the next section on Configuration Management.

Project events are usually scheduled by the project manager. The project team must then identify tasks to achieve the milestone events. The operations engineer must subsequently prioritize the tasks and assign the work to the shops. In collaboration with the shops the operations engineer will estimate the time required to accomplish each task and schedule the work to meet the project plan delivery requirements.

Because the shops support a number of programs it is essential that these tasks be coordinated among all project operations engineers according to priorities set by the Project Directorate. Weekly meetings shall be conducted to plan the work and evaluate progress. Participants will include operations engineers of each project and representatives of each shop or branch involved.

The operations engineer keeps parties informed of technical aspects of the equipment by writing Operations Fact Sheets for each aircraft. The Fact Sheet is an addendum to an Operator's Handbook and describes all flight crews and research investigators need to know about a vehicle that differs from the baseline configuration described in the Operator's Handbook. These Fact Sheets are vital for safety and mission success.

Operations engineers prepare maintenance and modification instructions that are not included in aircraft manuals or technical directives. These instructions include specifications (drawings) and procedures that ensure airworthy implementation, as well as inspection requirements that confirm conformance to the specifications.

Operations engineers prepare test plans and procedures for research flights and brief the project teams prior to flight so that roles and responsibilities of everybody involved are clearly understood. These plans and pre-flight briefings are vital to safety and mission success.

3.1 Configuration Control

The purpose of configuration management is to avoid unknown or unauthorized changes that increase the risk of accidents or failures. Depending on functional responsibility, the plans are written by the following:

- Project managers for research vehicles (DCP-P-016)
- Operations engineers for support aircraft (DOP-O-001)

- Mission managers for airborne science aircraft (DOP-Y-006)

Configuration management plans describe the roles and responsibilities of parties involved, assign authority for approval of configuration changes, explain the processes for implementing configuration changes, and describe the documents used to record configuration changes.

Regardless of who writes the plan, an operations engineer is the Operations Directorate's representative for configuration management of every flight vehicle operated at the Center. The responsibilities and authority are established in the configuration management plan for the assigned vehicle.

The Configuration Control Office issues drawing numbers and updates these drawings per engineering changes or redlines.[1]

Other functions of the Operations Engineer in the area of Configuration Control include the maintenance of up-to-date weight and balance documentation on the aircraft[2], and issuance of the Fact Sheet[3] which is in effect an addendum to the Pilot's Flight Manual.[4] The Fact Sheet describes in detail any configuration change that impacts the handling or flying qualities of the aircraft or the operation of its systems from a piloting point of view.

4.0 SYSTEM SAFETY

4.1 Role of the Operations Engineer in System Safety

Closely tied to Configuration Control is the System Safety Plan[5], which will vary in scope depending on the size of the project and the type of experiments involved. This plan specifies how the project intends to address and manage hazards as they are found.

Hazards may be identified on a hazard analysis, typically prepared by the Operations Engineer and/or appropriate Project Engineer(s), with inputs from outside sources that may have previously performed similar analyses on the items in question. Hazards may also be found from discrepancy reports filed on experiments or the airplane, discrepancies entered in the aircraft workbook, or system failure analysis performed on the experiments.

The project engineers are to identify hazards, assess the risks involved, and determine recommendations to management on how to eliminate, control, or accept the risk.

---

[1]DOP-O-022 Drawing Control Process
[2]See Section 7.1.4.
[3]DOP-O-006 Fact Sheets
[4]DOP-O-300 Flight Operations Manual
[5]DCP-S-004 & DHB-S-001 System Safety Plan

Hazards that cannot be eliminated or mitigated to a low enough severity and probability category become part of the project's "accepted risk list."[6]

5.0 FLIGHT PREPARATION ACTIVITY

5.1 Flight Preparation Defined

Flight preparation addresses the many activities related to readying an aircraft for flight. These can vary from a very large effort, when it follows a major modification, to an abbreviated "turnaround" process if the aircraft is to make successive flights without significant additional modification. The following paragraphs describe the "full blown" effort, which follows major modification of the aircraft. Appropriate deletions for the turnaround situations are negotiated between the Project Engineers and Operations Engineer.

5.1.1 System Functional Test (DCP-O-011)

These are very comprehensive tests of all aircraft systems, whether experimental or standard. In the case of non-experimental or standard systems conforming to Military Specs or Tech Orders, those documents will usually prescribe the proper functional tests. Experimental or highly modified systems require special formal procedures for functional test, which are generated by appropriate Dryden personnel or by a NASA contractor.[7]

The Operations Engineer must be involved in the development and execution of such functional tests, especially if the experiment in some way interfaces with the aircraft systems or if the safe operation of the aircraft depends on successful operation of the experimental system being functionally tested.

The nature of the experiment will determine whether System Functional Tests are repeated between every flight or only after long periods of down time, a major configuration change, or major system malfunction and repair.

5.1.2 Ground Vibration Tests (GVT) (DOP-F-730)

These tests are performed if a significant structural modification has been made that might have an effect on the flutter characteristics of the aircraft. In these tests, the affected portion of the aircraft is artificially excited by vibrator motors or "shakers" and the structural response is measured and analyzed by engineers with experience in structural dynamics (who are also responsible for generating the test requirements).

The Operations Engineer is not responsible for completing the details of these tests, viz., developing the procedures, gathering and analyzing the test data. However, the Operations Engineer is responsible for ensuring that no experiment, test or modification damages the aircraft, and is thus essential in the project determination of when GVTs

[6]DCP-S-002 & DOP-O-305 Hazard Management
[7]DCP-O-011 Preparation and Release of System Procedures

are required. The Operations Engineer is also involved in the preparation of the aircraft for a GVT and supports the completion of the test as required. GVTs may be time-consuming, depending on the type of modifications made to the aircraft, and the Operations Engineer is responsible for making the aircraft available for these tests.

5.1.3 Instrumentation Calibrations (DOP-R-405 & DOP-O-405)

When the instrumentation system is ready and functionally tested, the various data channels are calibrated. This involves the application of known inputs to the various sensors and a measurement of the signal received by the data recorders on instrumentation bus monitors. Calibration procedures are generated by the instrumentation engineer or technician. The calibration procedures may be more involved when special components, such as strain gages, must be instrumented and calibrated for flight.

5.1.4 Aircraft Weight and Balance (DOP-O-023)

Modifications to aircraft that alter its weight or the distribution of its weight require that a new weight and center of gravity (c.g.) location be determined. If the weight change is not extensive and if the specific location of weights removed or added is clearly identifiable then simple calculations will suffice, using the previous weight and c.g. locations as a baseline. However, in the case of more massive or complex weight changes, the aircraft is generally reweighed using either portable electronic scales or, preferably, the very accurate platform scales at the Edwards Air Force Base weight hangar.

The Operations Engineer is the keeper of the Weight and Balance book, and consequently is responsible for promptly updating it after any relevant change to the aircraft configuration, or after the required annual weight and balance.[8]

Some airplanes will be more sensitive than others to the c.g. limits allowed, but in all circumstances the Operations Engineer is responsible for determining the c.g. and maintaining the aircraft within its allowed limits or informing the project and management of any condition in which the potential for violation of aircraft c.g. limits exists. Such a situation is an operational hazard.

Occasional moments of inertia data are required for an aircraft or aircraft components. Such measurements are usually performed in Dryden's Flight Loads Laboratory under the direction of the Aerostructures Engineering Branch.

5.1.5 Combined Systems Test (CST) (DCP-O-011)

When all functional tests of the individual research systems are completed and the aircraft is essentially ready to fly, an all-up, end-to-end test of the entire aircraft and control room is performed. This test utilizes the Western Aeronautical Test Range[9]

[8]Air Force publication T.O. 1-1B-40: Technical Manual, Weight and Balance Data; and Naval Air Systems Command publication NAVAIR 01-1B-40: Technical Manual, Weight and Balance Data.
[9]DOP-F-100 through DOP-F-107 Western Aeronautical Test Range

(WATR), a staffed control room, preferably with the same personnel who will serve during actual fights, and with all required aircrew members on board. During Combined System Test (CST), engines are run so that all systems operate on aircraft power alone, and if required, the aircraft may taxi to a predetermined location on the taxiway. The CST, like the Functional Tests, is not repeated between every flight, but usually only before a first flight after an extensive modification to either the airplane or the control room, or both. A formal written set of special test procedures is developed for a CST, usually by the Project Engineers. Engineers who are principal researchers on the experiments to be flown must participate in the development of CST procedures.[10]

The CST plan will involve all aircraft systems, modified or standard, as well as the research or experimental systems. During CST all critical parameters are checked in the control room, if possible, for accuracy as well as functionality. The Operations Engineer must be familiar with the operation and interaction of critical flight components or subsystems, thus he or she should be intimately involved with both development and execution of the test and may even be responsible for collecting information from other project engineers to put together the test procedures.

5.1.6 Preflight Checks (DCP-O-011)

These checks are similar to System Functional Tests but are not nearly as comprehensive. They may vary in their content from flight to flight, and parts may be omitted for a succession of "quick turnaround" flights, but some form of preflight check is performed for every flight. Preflight Checks for "standard" systems are generally performed in accordance with Military Tech Orders applicable to the particular aircraft, or with their equivalent for non-military aircraft. Preflight Checks for experimental or highly modified systems are generated by NASA Subsystems Engineers or a NASA Contractor.[11]

Preflight Checks are covered in the various checklists completed before flights. The Operations Engineer is responsible for verifying that all needed Preflight Checklists are completed and modified as required. Checklists pertaining to the airplane are to be generated and modified by the Operations Engineer with inputs from other project members, including the avionics lead technician and the crew chief. The Operations Engineer should maintain the original versions of the checklists and make copies available to mechanics and technicians as required.

5.2 Flight Preparation and the Operations Engineer

Throughout the flight preparation phase, the Operations Engineer's role is, as always, that of the aircraft Technical Manager as described in Section 4.0, with added emphasis on his or her collaboration with other organizational elements involved in flight preparation, the engineers and technicians from various disciplines, all of who play an important part in this activity. Arranging schedules, determining support requirements,

[10]DCP-O-011Preparation and Release of Systems Procedures
[11]Ibid.

developing "workarounds" when difficulties arise, dealing with discrepancies, generating and/or approving test procedures are all part of the Operations Engineer's task.

In the case of an initial flight following a major configuration change, a Flight Readiness Review (FRR) will usually be conducted by an independent review board.[12] The Operations Engineer is among those required to brief that board, usually but not exclusively presenting pertinent data regarding any reconfigured aircraft hardware. The Operations Engineer may need to present other information, such as changes to Flight Operating Limits, changes to emergency procedures, and other pertinent items usually included in a new revision of the Fact Sheet.[13]

In addition to presenting information to an FRR board, the Operations Engineer may be asked to serve on a FRR board to review other flight projects.

The Operations Engineer participates in the approval process for all aircraft test procedures. This includes system functional tests, combined system tests, and preflight and post-flight checks, which originate locally. Procedures originating under contract or from another agency that are appropriately approved by that contractor or agency are subject to the Operations Engineer's review approval.[14]

Throughout the flight preparation phase, the Operations Engineer is the focal point for information concerning the status of the aircraft, and is the spokesperson as to its go/no-go condition.

5.2.1 The Operations Engineer and Life Support (DOP-O-007 & DOP-O-010)

The Life Support group performs all maintenance and modifications to the flight crew equipment and aircraft ejection mechanisms. This includes repairs as well as time-scheduled changes or upgrades. The Operations Engineer must coordinate with the Life Support group the availability of the aircraft for timely completion of all egress system work.

Cockpit modifications must not interfere with the safety of the aircraft crew during normal operations or egress, or in the event of an ejection. Cockpit modifications that potentially impact normal life support or egress systems must be reviewed by the Cockpit Committee.[15] All cockpit modifications, major or minor, should also be reviewed with the project pilots to ensure proper ergonomics. All work orders mandating cockpit modifications must be approved by the Cockpit Committee.

[12]DCP-X-009 Airworthiness and Flight Safety Review Process
[13]DOP-O-006 Fact Sheets
[14]DCP-O-011 Preparation and Release of Systems Procedures
[15]DOP-O-007 Cockpit Safety Review

5.2.2 The Operations Engineer and the Project Pilot

The Operations Engineer must keep all the pilots associated with his or her assigned aircraft informed of all modifications or upgrades on the airplane. Such information must also be documented on the aircraft Fact Sheets, which may take the form of changes or additions to the Pilot's Flight Manuals.[16] However, this information (including memo form addenda to the Fact Sheet) regarding changes to the pilot's interface with the aircraft should also be briefed personally to all pilots who will fly the aircraft prior to the first flight after incorporation of the changes.

6.0 FLIGHT SUPPORT ACTIVITY

Included in this area are those activities directly related to flight operations, among which the major events are as follows:

6.1 Technical Briefing

A briefing given by the Projects Office and engineering discipline personnel in which the technical objectives of upcoming flights and/or technical accomplishments of previous flights are presented. This briefing is normally given well before the scheduled flight to permit a thorough review of the flight plan by all concerned.[17]

The role of the Operations Engineer in a Tech Brief is similar to his or her role in a FRR, i.e., the Operations Engineer is to present any pertinent changes to the aircraft or its operation.

6.2 Crew Briefing

A briefing given by the Flight Operation Directorate, usually by one of the project pilots and assisted by other project members as necessary, in which the operational details of the flight are presented along with a run-through of the final flight test cards. Such items as crew assignments, weather forecasts, radio frequencies, chase requirements, mission rules, emergency procedures, etc., are discussed and reviewed.[18]

6.3 Day-Of-Flight Checks

Prior to take-off a set of procedures is followed in which all aircraft servicing is verified, and the step-by-step process of bringing all systems on-line is completed. As the aircraft undergoes final checks the control room instrumentation is verified for adequacy; also, pilot or crew entry occurs during this activity. The Operations Engineer is responsible for developing these procedures with the help of other project members and oversees their prompt and adequate completion. For simple situations in which aircraft modifications are minor, the standard checklists provided by Military Tech Orders or their commercial

[16]DOP-O-300 Flight Operations Manual
[17]DCP-X-008 Technical Briefings
[18]DOP-O-300 Flight Operations Manual

equivalent may suffice, but where new, complex experimental configurations are involved, a special checklist is developed by the Operations Engineer to ensure the dovetailing of pilot and ground personnel functions in order to attain the desired sequence of events. The day-of-flight checks conclude prior to the start of take-off, at which point the pilots test cards take over.

6.4 Mission Control (DCP-O-003)

During flight, the mission is usually but not always controlled from one of the control rooms at Dryden, where system health and aircraft performance are monitored real time using telemetry data downlinked from the test aircraft; the assigned flight controller provides the voice communication link between ground personnel and the flight crew.[19]

The Operations Engineer's primary task in the control room operations is to provide real-time information on aircraft subsystem operations. This may include troubleshooting and determining "workarounds" to safely complete the research mission.

The Operations Engineer may also be the flight controller[20] or a flight engineer; however, these roles depend largely on the nature of the research and project needs.

6.5 Flight Engineer

Operations Engineers, as well as other engineers, may also be assigned as Flight Engineers. Flight Engineers are usually needed for experiments too complex for a single crewmember to perform, viz., when a pilot is flying a high workload maneuver and must operate onboard research equipment simultaneously. The availability of Flight Engineers minimizes the need for multiple pilots on a single aircraft while maintaining the quality of the research data obtained. This role is particularly helpful for Operations Engineers in obtaining a better situational awareness of flight operations.

7.0 POST FLIGHT ACTIVITY

Post-flight activity involves recovery of the aircraft, any inerting of systems that may be required, instrumentation and aircraft system post-flight servicing/inspection, recording of any discrepancies, and similar activity. A post-flight debriefing is given by the pilot and others, including chase pilot(s) and control room team members if they have pertinent comments.

The Operations Engineer directs the aircraft activity as usual, and participates in any debriefings.

The post-flight period is relatively short and soon gives way to flight preparation if a turnaround is planned or a return to modification status if configuration is to be changed significantly.

[19]DCP-O-300 Flight Operations Manual
[20]Ibid.

8.0 PERIPHERAL ACTIVITIES

The foregoing sections of this handbook have presented the tasks that make up the core of the Operations Engineer's function, but there are others that frequently fall to him or her which are very important, the most significant of which are briefly described in this section.

8.1. Ad Hoc Review Committee Participation

Special committees are appointed from time to time for specific purposes, such as design reviews and flight readiness reviews. Membership for these committees is selected to match the major disciplines involved in the project under review, but since operational aspects and aircraft subsystems are usually involved, the membership generally includes an Operations Engineer.

8.2. Accident/Incident Investigation (DOP-O-305)

Accident or incident investigation usually involves an Operations Engineer. Depending on the magnitude of the accident/incident, an investigation may require a large board with requirements for formal reporting to NASA Headquarters, or a single investigator with only local, informal reporting requirements.

8.3 Source Evaluation Board (DCP-A-005)

Major competitive procurements will generally involve a formal source evaluation process to grade the various proposals and thereby assist in selection of contractors(s). Members of the Technical Evaluation Team usually include an Operations Engineer.

8.4 Engineering Design (DCP-P-016 & DOP-O-001)

The Operations Engineering group provides Dryden with an ever-increasing engineering design and analysis capability. The resources of the group may be accessed by all projects, including non-flying projects, needing support in mechanical or electrical design or analysis.

9.0 RESOURCES FREQUENTLY USED BY OPERATIONS ENGINEERING

9.1 Process Specification System (DCP-O-006)

Process Specifications give specific instruction on how to perform a particular process in a standardized way so as to achieve consistent results without re-inventing the process each time. References to specific Process Specs are to be found throughout this handbook as appropriate to the subject under consideration. The Operations Engineering Branch maintains an up-to-date Process Spec Manual in the Branch Office. The Process Spec System is administered by the Dryden Quality Assurance office.

9.2 Tech Order Library (DCP-S-018)

The Tech Order Library is administered by the Dryden Aircraft Maintenance Section. This library is a valuable source of Tech Orders for military aircraft, military specifications and standards, and other aircraft-related data. Up-to-date specifications and other drawings of standard military equipment are maintained as part of an extensive file and are available for quick access.

9.3 Photo Lab

The Photo Lab provides a variety of photographic services. Documentary photos can be taken on fairly short notice by experienced photographers. Aerial photograph and video capabilities are also available. This service can be very useful to the Operations Engineer who wishes to record significant stages in a reconfiguration process for future reference. A photographic work order is required to obtain photo services; both color and black-and-white photos are available.

9.4 Duplication Facility

A Reproduction Facility, or print shop, provides a variety of printing services. An important service for the Operations Engineer is the drawing copier for any size drawing.

9.5 Weight and Balance Hangar (USAF) (DOP-O-023)

The Air Force Weight and Balance Hangar located along the main taxiway at Edwards Air Force Base provides weight data for aircraft of almost any size. Massive platform scales imbedded in the floor structure give very accurate readings from which center-of-gravity location can be calculated. This facility is operated by the Air Force.

9.6 Flight Loads Laboratory (DOP-F-710 & DHB-R-004)

The Flight Loads Laboratory is used to perform combined mechanical and thermal load tests of structural components and complete flight vehicles that simulate actual flight conditions. The lab is also used to perform strain gage loads calibrations on aircraft components, such as actuators and links, and on complete aircraft structures, such as wings, tails and fuselages, for flight loads measurements. Proof loads tests for flight certification of modified aircraft structures and new aircraft structural components are also performed at the Lab. For thermal and/or mechanical structural testing of aircraft, the Operations Engineer is responsible for providing the aircraft in its proper configuration, and generally also has the responsibility for design and fabrication of aircraft laboratory hardware required for testing, i.e., load reaction fittings that attach directly to the aircraft. The Operations Engineer also participates in Test Readiness Reviews and is often an active participant during performance of the tests.

9.7 Walter Williams Research Aircraft Integration Facility

The Walter Williams Research Aircraft Integration Facility provides flight simulation and data recording capabilities that may be useful in determining aircraft operation at different flight conditions. Flight test cards are usually flown on a simulator by the project pilot or a project engineer before being flown on the airplane. Some simulators include hardware in the loop capabilities that is useful for testing and troubleshooting components.[21]

[21] DOP-F-710 Simulation Facility